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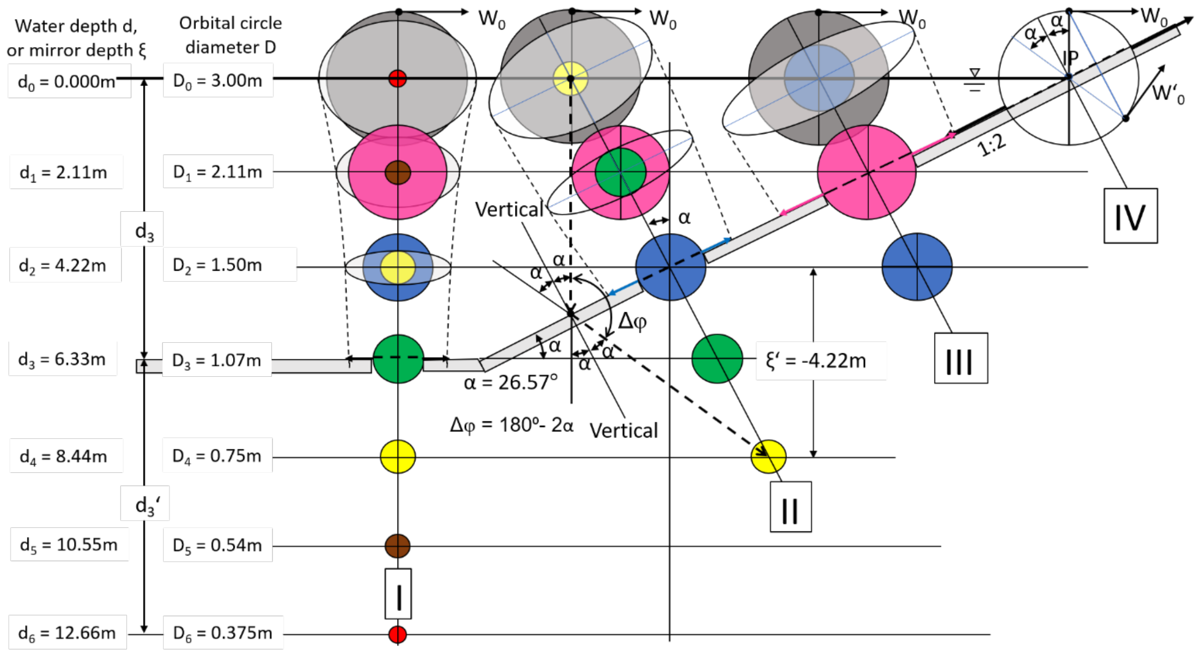
New Theoretical Approach to the Influence of the Sea-Bed-Inclination on the Water Wave Motion in the Range of Decreasing Water Depth

The linear wave theory according to Airy-Laplace, which up to now has been used mainly by engineers, is on the one hand limited to the assumption of a flat sea bed and on the other hand violates the theorem of conservation of mass (continuity condition). This is no longer the case with the author's new approach, which involves an extension of the mirroring procedure referred to by Schulejkin (1956) on level ground, now to ground inclinations $0 \leq \alpha \leq 90^o$. According to this approach, the deep water- waves with circular orbital movements interfere with likewise circular orbital movements of smaller diameter, which are assigned to the waves reflected from the inclined ocean bottom. Taking into account the phase jump $\Delta\varphi = \pi - 2\alpha$ between incident and reflected waves, which depends on the inclination of the ocean bottom, elliptical orbital paths are formed over inclined ocean bottoms, the long main axes of which rotate around the inclination angle α.
With increasing approach to the ground on the one hand and to IP on the other hand, the long axes of the ellipses increase at the expense of the short axes until the latter disappear completely on the ground and the local long axes take twice the initial orbital diameters, see figure.



In analogy to the optical reflection with equal angles of incidence and reflection α, a vertical incidence beam is assumed here with respect to reflection axis II, which hits the inclined surface of the ocean bottom and is reflected from there with the starting angle α related to the perpendicular.

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In the negative mirror depth ($\xi' = -4.22$m corresponding to $d_4 = 8.44$m) the orbital circle diameter reduced to $D_4 = 0.75$m according to $D = D_0 e^{-2\pi\frac{d}{L}}$ is obtained.

Since the horizontal orbital velocity vector W_0 of the wave crests on the circumference of the orbital circle is assumed to be the reference point, the phase jump $\Delta\varphi$ occurs here between the incoming and outgoing beam as a rotation angle $\Delta\varphi = 180 - 2\alpha$. If the velocities (by magnitude and direction) to be assigned to the respective virtual orbital circles are superimposed on those of the respective incident circular orbital motions of the initial deep water waves, the result is the represented elliptical orbits rotated by the angle α. It was taken into account that the orbital velocity vectors on their orbital circles have opposite directions of rotation.
The obtained result is shown here in principle for a wave of height H = 3.0m and length L = 38.00m with respect to the given boundary conditions.

The representations of the other parameters, which refer to the dimensions of the associated model investigations, can be taken from the original work of Büsching, Fritz (2019): "Vibration Interferences in the Limited Orbital Field of Sea Waves in Theory and Physical Model":
https://doi.org/10.24355/dbbs.084-202002031131-0

German Version: https://doi.org/10.24355/dbbs.084-201912201126-0.

It should be noted:

For the time being, the acceptance of the found results seems to be impaired by the fact that the author used a relatively complex spectral method developed by himself for the analysis of irregular waves in his model investigations, cf. his earlier publications. This method has hardly been reproduced by other researchers.

A particularly important result is the definition of the complex reflection coefficient $\Gamma = \frac{H_r}{H_i} e^{i\Delta\varphi}$. This states that the reflection of water waves is not only determined by the height ratio $C_r = H_r / H_i$, but also by the phase shift $\Delta\varphi$ (phase jump) between the incident and reflected wave. This fact (which also exists with electromagnetic waves!) has apparently not yet been sufficiently confirmed by other researchers.

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